Assessment of the Effectiveness of the Integrated Air Defense of Multinational Peacekeeping Crisis Reaction Forces

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1. The Specific Nature of the Organisation of the Air Defense of Multinational Peacekeeping Forces (MPF AD).

MPF AD should be organised in accordance with the UN mandate (UN Security Council Resolution). The UN mandate states:

- The objectives defined for MPF and their AD;
- The basic methods of task execution;
- The restrictions on AD and MPF air force actions in the airspace;
- The limits applying to airspace use by air force of the contending parties and contiguous countries in peacekeeping regions and some other regions.

Among the main objectives assigned to MPF AD are the following:

- Control over airspace in the peacekeeping regions and in the air safety zone (ASZ),
- Coordination of airspace use,
- Organization of cover for MPF and for the units they protect.

Control over airspace in peacekeeping regions is a complicated organizational and technical goal. The complicated character of the goal is due to the requirement for guaranteed all-altitude control in the zone under MPF AD jurisdiction and also the need for 24hr radar surveillance and the extremely limited time frame for reaction to possible attacks in the airspace. In some cases the multinationality of the peacekeeping forces is also a significant factor.

The requirement for all-altitude control (1) over the zone under MPF AD jurisdiction ($\mathbf{H}_{ad}$) is determined by the necessity to control airspace at all altitudes available to aircraft of all types ($\mathbf{H}_{max}$) at the disposal of the contending parties as well as at the disposal of neighboring countries.

$$H_{ad} \geq H_{max} \quad (1)$$

There are complications concerning the requirement for 24hr duty on airspace surveillance. They are as follows:

- First, the demand for several specialist groups which would replace each other and thus provide twenty-four-hour maintenance of the equipment.
- Second, the necessity to carry out the task of control over a long period of time. Overcoming conflict is a slow process, and the moment of final reconciliation of the parties is often protracted which is why the peacekeeping operation could last as long as the process of negotiation. In isolated cases, the peacekeeping operation forming part of one and the same UNO mandate might continue for several months or even years. The mission of constant airspace control has to be carried out throughout this period.

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At the same time some peacekeepers return home after completion of their military service and new peacekeepers must undergo the appropriate course of training and take the place of their predecessors. Over a certain time span they undergo a commissioning procedure for peacekeeping units including MPF AD elements. This hinders the effective use of radar devices and the accomplishment of the airspace control task.

Third, the limited operating characteristics of radar equipment. The equipment should regularly undergo maintenance if it is not in battle mode operation; if the equipment operational date has expired it should be replaced. Therefore, it is hardly possible to operate with only one radar station for MPF AD, even if the station is capable of detecting air targets in the peacekeeping region. There should be at least two radar stations.

With reference to MPF AD units we can conclude that there should be more radars than the design specification for the single coverage of the zone under MPF AD jurisdiction.

Looking at this problem in the light of tactics we should take into consideration possible cadre casualties as well as losses of armament units used for radar control over the airspace. These losses might be a consequence of force implementation by one of the contending parties against the peacekeepers. Predictable losses due to participation in military actions can be compensated for by timely creation of facility and force reserves. Otherwise, if there are no reserves, theoretically and practically there are several options for filling a gap in the radar field of the MPF AD:

- For a period of a few hours the task can be carried out with the help of aircraft and helicopters for radar patrol provided that meteorological conditions are satisfactory;
- If several days coverage are required ship radar assets can be used in the coastal regions;
- Over a prolonged period of time the task can be accomplished by new radar reconnaissance units which include one member from every MPF country in accordance with an additionally coordinated agreement.

Thus, 24hr airspace control can be accomplished under the following conditions:

- Location of a sufficient quantity of reliable radar installations in the field and the necessary battle crews for 24hr operation,
- Deployment of the required number of radars to create a solid radar field in the peacekeeping region and in the air safety zone if such are established,
- Timely creation of adequately trained staff reserves and constitution of armament reserves to compensate for probable losses due to participation in military actions,
- Timely maneuver of the radar intelligence forces assembled for peacekeeping operations. At the same time it is necessary to allow for the possibility of using radar reconnaissance assets installed on troop carriers and ships in the coastal area.

Organization of co-operation with the air defense capabilities of neighboring countries whose peacekeeping contingent forms part of MPF or where such countries agree to occasional participation in the task of radar control of airspace in peacekeeping regions.

It is acceptable, for airspace control, to use certain radar ground reconnaissance assets at the disposal of peacekeeping crisis reaction forces. Nevertheless, this does not fully solve the existing problem due to the limited capacities of these radar assets with regard to the range and altitude of detected targets.

The most significant factor in the organization of MPF AD is the time limit. The small amount of time that the joint air defense has at its disposal is first of all dictated by the limited area of the peacekeeping operation and high airspeeds of the aircraft.

Let us take for instance Kosovo, (KFOR peacekeeping operation) the territory of which is some 11 00 square kilometers in extent. If we consider the territory of Kosovo as a square then we can obtain a linear measure, i.e. a square side along which, hypothetically, an intruder can infringes the order of airspace use. The length of one square side is approximately 150 km. Supposing that the whole of the air safety zone is controlled by MPF AD, then the complete course of an aircraft from the moment of its detection at the edge of the air safety zone to its exit from the peacekeeping region would be 130 km. Even at subsonic airspeed (Vi ≅ 300 meters per second) its presence in the zone of impact would be no more than 7,2minutes.

A somewhat more favorable time balance can be achieved for MPF AD when the intruder is a helicopter at low airspeed (Vi ≅ 75 meters per second). In this case its presence in the zone of impact would be approximately 29 minutes. The calculation is made for ideal conditions when the air target is constantly detected throughout its course. Nevertheless, time balance with respect to the intruder is practically minimal. I.e. time available for impact ($\mathbf{T_{disp}}$) and time needed ($\mathbf{T_{need}}$) 12.

$$T_{disp} \approx T_{need} \tag{2}$$

This kind of time balance means zero tolerance of all possible unjustified losses of time in major MPF AD units. Losses can be avoided or significantly reduced in four areas:

1) In the control system, by automation of the control procedure on the use of airspace by civilian and military aircraft and also by automation of the whole control cycle for air defense reconnaissance and combat assets. Here, great emphasis is placed on dynamic elimination of weaknesses in knowledge of the active control language of control by the C2 officers in the MPF AD for whom this is a foreign language. Similarly, this can be applied to the handling of automated control equipment used by specialists at standard work stations;
2) In radar reconnaissance systems by realizing realization of all the potential capacities of radars for target detection at maximum range. This can be achieved by automisation of detection procedures, modernization of locating devices and constant target tracking in intensive natural noise. In isolated cases intensive jamming can be applied;
3) In short and medium range SAM units by optimal positioning for maximum target shoot-down capability and by organisation of operating procedures.
4) In the MPF air force, by reducing the necessary number of radar patrol aircraft required in order to reconstruct the radar field and its development in the directions of potential threat. Scheduled patrols of airspace by interceptor crews can be organised when there are no other assets capable of acting in a certain part of a zone under MPF AD jurisdiction or in case of necessity.

Special attention should be given to the multinationality of MPF AD. Let's take as an example the air defense assets of the Dutch and Belgian airmobile brigades which are recruited and trained for peacekeeping missions.

The 11th airmobile brigade (Holland) has 3 platoons of portable SAM batteries at its disposal. In every platoon there are 24 Stinger type man-portable guided missile (MPGM) units, making in all 72 Stingers. The Belgian brigade has a battery of MPGM containing 18 "Mystral" type MPGMs. In the peacekeeping brigade of the Russian Federation, which acts as part of the multinational division "North" in Bosnia and Herzegovina, air defense forces also consist of MPGM subunits.

The maximum range of this kind of device does not exceed 6 km and the maximum altitude is no more than 3500 m. Air intruders are unattainable for air defense systems used for the self-defense of mobile peacekeeping brigades at heights of over 3500 meters.

The Dutch and Belgian brigades are members of the multinational airmobile division "Center". According to the media, the primary problem of equipment support for the Division "Center" is the variety of armament

and military equipment models. Despite the efforts made by NATO on standardization during the last 30 years, at the present time the division is equipped with:

Helicopters – 6 types,
Artillery – 6 types,
Small arms – 9 types,
Antitank weaponry – 7 types,
Military vehicles – 10 types.

In addition, each type may have up to 4 modifications. Air defense armament is approximately in the same situation.

Thus, various types of armament of similar class and mission are widely used in MPF. They can significantly differ in their battle capacities from one to another. In addition to this, the quantity of armament of similar class available to military units and formations of equal level can be totally different. These two things are objective factors which complicate organization of MPF AD.

The next conclusion concerns the absence of proper radar intelligence assets in airmobile brigades; their availability would enable build up of the required radar field. These brigades do not have short and medium range SAM units which are essential for MPF AD to combat especially dangerous intruders and in particular the transports used for delivering military supplies to the contending parties.

The absence of the above mentioned air defense assets in the peacekeeping brigades demands means that they should be incorporated into multinational peacekeeping divisions or into units that are subordinates at a higher level, i.e. at the level of international security forces commander. The latter option seems to be the most rational from the organizational and economic points of view.

2. Influence of the Phased Deployment of MPF in the Peacekeeping Region.

In accordance with the Military-technical agreement between the international security force (KFOR) and the Governments of the Federal Republic of Yugoslavia and the Republic of Serbia, 72 hours after the entry-into-force day (EIF) of the agreement, all the forces and assets of FRY AD are to be completely withdrawn from Kosovo and other parts of Serbia, i.e. outside the 25-kilometere air safety zone. At the same time, the complete withdrawal of all Federal Republic of Yugoslavia forces from Kosovo is to be completed by the end of the 11^{th} day, which is 8 days later than the EIF. The speed that the MPF should use when deploying is calculated on the principle of "avoiding any vacuum in security issues". This fully concerns the deployment of MPF AD.

Consequently, there should be advanced air defense units in the leading columns entering the peacekeeping region; the radar should be deployed simultaneously or even before removal of the radar station of the departing government forces.

Cover of the MPF from the air threat during the initial phase of deployment is theoretically possible in three ways:

- With the help of AD assets for immediate cover of both organic and attached units at low and limit low altitudes;
- With the help of interceptors from one or more of the MPF countries, based on aerodromes of neighboring countries and capable of performing duties in the air or on the depot aerodrome. Interceptor control is carried out from the air command post (airborne warning and control system, AWACS);

- With the help of SAM systems within the altitude and range zone of neighboring countries and subordinate to the international security commander, provided there are necessary agreements that meet the demands of international law.

The border air defense zone of neighboring countries can be viewed both as a means of organization and as an objective for their air defense, i.e. to cover a part of the MPF in the peacekeeping region during the initial phase. Air defense systems of this kind are not only multinational but intergovernmental. This affects the organization of MPF AD. The system must have the required communication channels and data transfer links to ensure this type of control. It is reasonable to incorporate coordinator officers into the operation groups of the MPF headquarters and of neighboring country AD headquarters.

During the following phases of the MPF AD peacekeeping operation, it is possible and expedient to continuously cooperate with the air defense border zones of neighboring countries.

From the outset, i.e. the crossing of the state border or the peacekeeping region border, international security forces should have cover from the air threat. During the initial phase of the peace support operation, (PSO) due to the lack of absolute control over the situation it is highly probable that armed conflicts between the contending parties might suddenly break out and all kinds of armament might be used, including air attack.

At such times, the commander in chief of the MPF is under great pressure when controlling the peacekeeping forces entering designated areas and he can not devote all his time to air defense objectives at the expense of the major objective, i.e. control of peacekeeping force deployment. Nevertheless, air defense missions still exist; and they tend to be rather complicated when the contending parties have small numbers of air attack assets at their disposal due to the limited volume of reliable data on the air situation.

The control objectives of MPF AD are specific and their accomplishment demands special training and appropriate control skills from the corresponding officials, which is why is it preferable and expedient to place all responsibility on one of the deputy commanders in chief of the MPF or even better with a deputy commander in chief for air defense issues. The post of deputy commander in chief of MPF on air defense issues is therefore an essential one during the initial phase of PSO.

The rule which has emerged from practical experience demands top-priority entry and deployment of joint air defense forces in the PSO region and demonstrates the necessity of having a basic MPF AD unit at the disposal of the commander in chief of MPF. The objective of the basic MPF AD unit is to provide the commander in chief of the MPF with reliable radar data on the air situation and to frustrate possible plans of the contending parties to have armed conflicts in the airspace or to attack peacekeeping forces.

A basic MPF AD unit for a PSO region with a total territory of 10-15000 km 2 might be configured as follows: one radar reconnaissance battalion (or advanced company), 2-3 SAM battalions of short and medium range and a CAM system (computer aided management system) for the MPF AD to ensure interoperability of the air defense assets belonging to the national peacekeeping contingent.

It is expedient to detach the basic air defense unit from one country or from a regional military organization. The head of the basic MPF AD unit completes a course of professional training as deputy commander in chief of MPF for air defense issues. Following the full-scale deployment of MPF and the decline of the air threat level in the PSO region, it is reasonable to take a new decision on the organization of MPF AD including the configuration of its basic unit.

Control of MPF AD in the peacekeeping region might be complicated due to double subordination of separate national peacekeeping contingents. With regard to administration they are subject to national command, with regard to operation control they are subordinate to the commander in chief of MPF. In isolated cases, direct operational subordination is conditional. In order to carry out a decision it is necessary to get not only the

order from the commander in chief of the MPF but also confirmation from the senior national military commander in the MPF headquarters. Naturally, this complicates the system of control.

There are other factors that complicate control of MPF AD:

- Heterogeneity of the applied air defense assets;
- Peculiarities of the national legal system on questions of peacekeeping actions;
- Problems of reliable linguistic support for peacekeeping operations and peculiarities of the national psychological mentality of the peacekeepers in terms of multinationality.

The specific nature of MPF AD control places high demands on its automation, on reduction of the number of control levels to a reasonable amount especially in cases of tactical problem solving. Therefore, on completion of full-scale deployment of MPF and despite the expected decline in the air threat level the mission of direct control over air defense forces should be carried out by the deputy commander in chief of MPF for air defense issues. This is why the post on the MPF control staff should be maintained until complete elimination of the air threat.

The deputy commander in chief of MPF AD should have a battle control group to plan application of all MPF AD forces and control them during peacekeeping operations. Among the members of the battle control group should be the officers of those countries that have committed their sub-units to the MPF AD and where complicated legal standards on national peacekeeping contingent participation are in force. Naturally, if there is no air threat there is no need to maintain the post of deputy commander in chief of MPF AD and the appropriate specialist staff.

The nature of resistance during peacekeeping operations (high dynamism and transiency, incomplete data and increased level of threat from even one ASSU (air and space strike unit) is practically the same as against aircraft in the course of normal combat operations. This is why the joint air defense of the MPF must be of the same quality that of a national air defense. This requires high effectiveness, stability, mobility, flexibility, and the capability to solve the unexpected problems. All these qualities need to be evaluated in order to improve the MPF air defense system.

3. Purpose and Tactical-Technical Basis of the Interactive Model System for MPF Joint Air Defense.

The system of interactive models (CIM) is intended for the design of complicated real time technical systems including the solution of problems of planning, organization and preparation of the joint MPF air defense and research into its effectiveness. The principal questions that can be formulated with the help of the CIM are armament, build up and functioning of the joint MPF air defense and its sub-systems and sub-units. Moreover, common and special problems of air traffic control (ATC) in the peacekeeping region can be solved with the help of the CIM.

At the present time there are still ongoing on peacekeeping operations in many regions of the world. In some of them there is still a serious air threat to the peacekeepers as well as to their efforts in supporting peace. This threat can come from contending parties or from third countries that support one of conflicting parties and deliver military supplies to it by air.

The sources of air threat sources are the ASSU's that are being constantly modified. In response to this, new air defense assets are designed and the old ones modified, and new ways and methods of employment are being actively worked out. Development of operating means and methods for ASSU's and AD significantly influences air defense organization for peacekeeping operations.

Under these circumstances the effectiveness of MPF AD at the required level is an acute and extremely complicated problem which demands well-grounded decisions and considerable financial resources.

In order to exclude unjustified expense and to save UNO resources, it is necessary to have highly efficient decision making tools for joint MPF AD organization issues in the designated peacekeeping region. At this point it is necessary to choose the most rational combination of air defense assets from all the possible units that can be submitted by national armed forces for inclusion in the MPF AD structure.

In the event of any alteration of the UNO mandate, the command and the staff of the MPF AD should prepare a new decision on joint air defense as quickly as possible; this is to be accomplished with the help of the appropriate hardware and software; it should be put into practice in variants to suit the new circumstances of the evaluation of all-round effectiveness of the modified AD.

The specially designed interactive model system (IMC) of the combat activities of different forces and air defense assets enables this kind of possibility. The IMC is a new software product which makes it possible to design the following, in the Windows system:

1) Mathematical models of ASSU equipped with any possible variant of combat airborne weapon. There is a hypothetical variant that for research aims a random set of onboard equipment and armament can be chosen.
2) Mathematical models of ASSU actions. Actions of various scale and intensity are designed and they range from single airspace object action to delivery of massive air and missile attack.
3) Mathematical models of air defense assets (radar stations and systems, air defense missile systems, fighter-interceptor, electronic command post automation system, etc.)
4) Mathematical models of air defense units of random composition and configuration.
5) Mathematical models of bilateral combat actions formed entirely of software blocks that simulate ASSU unit employment processes and reciprocal actions of air defense units.

The IMC is a highly effective tool for short term problem solving for air defense. We consider the following to be at the top of the problem list:

- Assessment of the effectiveness of the deployed air defense units and exposure of their weak aspects;
- Substantiation of trends in new air defense facility design and modernization of outmoded air defense assets (electronic command post automation system, radar stations, air defense missile systems, radar intelligence and electronic warfare assets, etc.);
- Substantiation of nomenclature and procurement of new equipment for rearmament of air defense units;
- Design of new and modernization of existing air defense units in order to provide the required efficiency. The principal elements of the given system are:
  - choice of the armament and military equipment produced for air defense forces and assets in a specific region;
  - substantiation of the numerical composition of formations, units and sub-units of army branches and of specialized air defense troops;
  - build up of the air defense unit and its structural optimization depending on the problems set;
  - the choice of a rational control system for the air defense unit;
  - substantiation of methods and order of interaction between the different elements of the air defense unit;
  - substantiation of the combat order of units and sub-units of army branches in the air defense unit for the practical solution of specific air defense problems;

- Creation of different simulators and simulation systems for single operator training on separate systems, for reduced and full combat crew operating information and firing assets, and for combat crew operation of fighter-interceptor direction posts and command posts;
- The set-up and execution of command and staff exercises and war games in real time and for purposes of air defense and non-strategic antimissile defense;
- Planning of air force combat action to penetrate air defense and to deliver air attacks on designated targets;
- Creation of principal modeling systems (stands) and specific software for the design and testing of armament and military equipment available to the air defense unit.

Some examples of principal modeling systems are:

- A system of simulation models for assessment of the effectiveness of combat action, of the vitality and noise immunity of a radar reconnaissance system, and of a SAM defense and fighter cover air force unit;
- Simulation and analytical model system for assessment of the effectiveness of combat actions and of the vitality of electronic warfare units of AD;
- A research system for selection and debugging of optimal algorithms for solution of problems on combat action control and for radar data processing;
- A system for the calculation processing, during the combat action planning phase:
  - of operational and tactical capacities of air defense units
  - of combat estimated losses
  - of armament and military equipment nomenclature and their quantity in the air defense unit reserve,
  - of staff reserve.

The solution of any of the above problems is accomplished in accordance with the basic data conditions and limits set by the Customer and coordinated with the Executor.

IMC is aimed at researchers and specialists working on the problem of the opposition between air defense and air and space strike units, it is also aimed at designers of future air defense and air force systems, at air defense, air force staff officers and MPF staff. The IMC user interface is fairly simple and easy to master.

The principles of IMC design, structure, algorithms and the detail of its constituent parts operation are not confidential. The initial data and the results of the research may however be of a confidential nature.

4. Characteristic of the Modeling Subjects.

The basic subjects of modeling are bilateral combat actions between the air defense unit and the air adversary. They are modeled as a whole and in parts; at this point there is a possibility of termwise modeling of separate sub-systems (control system, radar reconnaissance system, air and space strike units, air defense aircraft unit, electronic warfare units and sub-units). The structure of the basic part of the IMC which includes models of ground air defense forces and assets is shown in figure 1 (appendix 1).

Modeling also concerns various types of air attack assets: airplanes, helicopters, ballistic missiles, aeroballistic missiles, cruise missiles, etc.

All types of air attack assets are characterized by basic parameters, by functional structure, combat operation logic and movement dynamics.

Command stations and control stations with automated systems, means of data provision (radar detection stations), ground and air fire power (FM) of different types, electronic warfare assets, shields against high-accuracy weapon and communication assets are modeled as elements of the air defense unit.

All types of information, fire control and other capabilities included in the air defense unit are characterized by basic tactical and technical parameters, by functional structure and by their combat operation structure.

Control stations (CS) are characterized by their functional structure, their control algorithm system, and by the logic of the battle crew work.

The structure of the air defense unit system of control is selected as a multilevel and can reconfigure during combat actions (dynamic structure), which helps to take into account the possible loss of air defense forces.

The additional modeling subjects are subjects under cover. All subjects under cover can be characterized by a number of parameters including the vulnerability factor.

IMC is suited to modeling not only in terms of time close to real time, but also for modeling on an accelerated time scale, which helps the command post to evaluate a number of MPF AD action variants and to choose the most effective when decision making on the interception of strike aircraft or against intruder actions in the peacekeeping region or in the air safety zone.

The simulation model system using Windows can be successfully installed in the MPF AD local or regional computing system for the creation of complicated air situations, so as to train air movement control operators or to train combat control officers at the command post. With its help it is possible to evaluate the aptitude for control of all officials in operational and combat groups at command posts. At the same time there is a possibility of defining any alteration in control quality due to the lack of skills and knowledge of operational control on the part of MPF control specialists for whom this language is not their native tongue.

This highly effective tool for assessment of the effectiveness of MPF AD, i.e. the interactive model system, has a wide sphere of application for peacekeeping goals as well as for detailed research into problems of opposition between air attack and air defense assets.

Conclusions

1. The design of joint MPF AD should be carried out in accordance with the rules of opposition in airspace between attack and air strike defense assets assumed for the purposes of air defense design in any given nation. The effectiveness of MPF AD at every stage of the peace support operation (PSO) should correspond to the problems posed and to the solutions envisaged.

2. One of the primary objectives of MPF AD is to control aircraft employment in the zone of responsibility. The solution of the problem at definite stages of the PSO can be fully committed to the MPF AD which should be taken into account when setting up joint air defense control and radar reconnaissance systems. Later, there is a possibility of using part of a nation's air traffic control (ATC) assets for the joint execution of control function in the conflict region until such time as the problem can be transferred to the national air traffic control center.

3. All other things being equal, control of the MPF AD forces is extremely difficulty due to their multinational composition. The basic factors that affect MPF control are: type variety in the weapons applied, insufficient knowledge of the operational language of control by the specialists of certain national peacekeeping contingents, absence of the necessary skills in using the automated control system, differences in legal standards on peacekeeping activities, and negative manifestations of national psychological mentality in a multinational environment. The increased complexity of MPF AD control

makes it necessary to provide a post of deputy commander in chief of MPF on air defense issues and the appropriate specialist group in the command post staff.

4. It is impossible for MPF AD to solve all the problems it is faced with in accordance with the UNO mandate with respect to air defense crisis reaction forces, due to the lack of radar reconnaissance assets and cover assets against ASSU attacks carried out from 3500 m altitude. In the event of an air threat, the air defense assets at division level should be attached to the MPF or to the basic air defense unit directly subordinate to the MPF commander in chief, which has increased capabilities detected target range.

5. The initial phase of PSO, with deployment of MPF is a special element in the theory and practice of peacekeeping. During this phase there is still a high possibility of military confrontation between the conflicting parties and also a possibility of force application against the peacekeepers. This particularly applies to the air threat to MPF and to assets under their guard. The discrepancy between the maximum air threat and the lack of deployed and warfare capable MPF AD forces and assets at this stage can be resolved by full cooperation with the air defense and air forces of neighbouring countries, by cooperation between PSO participants and by obtaining the assistance of the air defense forces of the regional military organization which has provided the greatest number of peacekeepers to the MPF staff.

6. At the end of the initial phase of PSO, and provided there is enough control over the conflict situation, the air threat should decrease in the zone under MPF AD jurisdiction and this will lead to reconsideration of the quantitative organization of active air defense assets.

7. The effectiveness of joint air defense action can serve as an integral base criterion for initial and subsequent decisions on organization and improvement of MPF AD. Assessment of the all-round effectiveness of MPF AD with the use of different types of software and hardware will give the basis for decision making and efficiency. Interactive models of the processes of opposition between ASSU and AD in airspace are an example of future software devices of this type.